PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Improvements relating to Strain Gauge Load Cells.

We, W. & T. AVERY LIMITED, a British Company, of Soho Foundry, Birmingham 40, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to strain gauge load cells of the kind (hereinafter called the kind specified) comprising an elastic load-supporting member to which is secured at least one strain gauge so that elastic deformation of the load-supporting member when under load is physically communicated to the strain gauge or gauges with a consequent proportional change in the electrical characteristics of the gauge or gauges. The strain gauge or gauges may for example consist of resistance or piezo-electric elements, and usually a plurality of strain gauges are mounted symmetrically on the load-supporting member so that by connection of the gauges in a bridge circuit it is possible to obtain a cell output which is a more accurate measurement of the load imposed on the cell than by use of a single gauge.

Ideally, the change in characteristics of the strain gauges should be directly proportional to the magnitude of the applied load. As is well known, at low loads there is an inherent non-linearity error in the gauge output, for example, in the range from zero load to about 5% of the rated capacity of the cell, and in order to obviate such error, it has been proposed to pre-stress load-cells to make them work in the linear part of the gauge output characteristic. Such pre-stressing proposals have been made in order to compensate for non-linearity errors in dependence upon whether the particular cell is required to measure an applied compressive external load or an applied tensile external load.

In the majority of weighing applications such lack of linearity in the vicinity of zero load conditions is not serious since the dead weight of for example the super-structure of containers which transmit the weight of the material to be weighed to the cell pre-loads the cell to a range in which the gauge characteristics and hence the cell output are substantially linear. However, there are some applications where this pre-loading is absent, for example when the load cell is built into a crane weigher where the dead weight of the crane hook insufficiently loads the cell, and in material testing machines where it is required to stress a specimen continuously from a compressive load through zero to a tensile load.

Our object in the present invention is to provide an improved construction of strain gauge load cell which is suitable for use in measuring both applied tensile and compressive loads.

The present invention consists in a strain gauge load cell of the kind specified, which is pre-stressed to make it work in the linear part of the gauge output characteristic over a range extending between an external tensile load through zero to an external compressive load, in which the load supporting member is an elastic cylindrical column provided with relatively rigid axial-end cross-pieces which are interconnected either by similar parallel relatively rigid side members respectively disposed symmetrically on opposing sides of the column and parallel therewith or by a relatively rigid tube co-axially surrounding the column, the side members or tube in the unstressed condition being alternatively either shorter or longer than the axial length of the

column in the unstressed condition, the arrangement being such that by reason of the interconnection with the cross pieces and the disposition of the column therebetween, prestressing of the side members or tube occurs and pre-stresses the column to an extent which is greater than the sum of half the maximum stress to be applied to the cell as a whole and the stress which must be applied to the elastic column before a linearity error becomes negligible.

In addition to being most suitable for use in material testing machines where it is desired to stress a specimen continuously from a compressive load through zero to a tensile load, the cell of the invention can also be used to measure alternatively, either an applied compressive or a tensile load.

Two typical examples of the practical realisation of the invention, and modifications thereof, will now be described with reference to the accompanying drawings, in which:—

Figure 1 is an elevation of the first example; and

Figure 2 is a sectional elevation of the second example.

Referring initially to Figure 1, a load cell 5 comprises an elastic load-supporting member in the form of an elastic cylindrical column 6 and a housing 7 consisting of a pair of parallel spaced apart substantially rigid cross pieces 8 which are interconnected at their ends by a pair of side members 9 integral with the cross pieces. The gap between the cross pieces 8 is somewhat shorter than the length of the column 6, and the column 6 is interposed between the cross pieces 8 after forced further separation of the centre regions 10 of the cross pieces 8 so that, upon release of the cross pieces 8, the elastic column is retained therebetween and is subjected to an axial compressional stress equal to the sum of the tensile stresses set up in the side members 9 by their stretching to receive the column 6.

Referring now to Figure 2, the cell 12 shown therein comprises an elastic load-supporting member again in the form of a cylindrical elastic column 13 which is mounted between a pair of spaced parallel cross pieces 14 with the ends or edges 15 of the two cross pieces 14 bolted at 16 to flanges 17 at the opposite ends of a tube 18 of shorter axial length than that of the column 13 and coaxially surrounding the column 13. By virtue of the shorter length of the tube 18 the column 13 is again prestressed in compression.

In modifications of the cells 5 and 12 the ends of the elastic columns 6 and 13 are rigidly connected to the cross pieces 8 and 14 with the ends or edges of the cross pieces inter-connected by the integral or separate side members 9 or tube 18 of longer instead of shorter length than the columns 6 and 13, whereby the columns are pre-stressed in tension.

In each of the cells 5 and 12 and the modifications thereto strain gauges (not shown) are bonded in known manner to any one or all of the pre-stressed members of the cell to provide one or more resistiv arms for a bridge network. Preferably passive further gauges are bonded to parts of the cell so these passive gauges are not stressed when the cell is loaded. The passive gauges are connected in the bridge circuit for temperature compensation again in accordance with known practice.

Considering the cell 5, as an example, in greater detail, and assuming the side members 9 are rigid, are of equal length, and are symmetrically disposed on each side of the column 6 with tensile loads of $P/2$ units set up in the side members 9, then the column 6 is prestressed in compression by P units by the side members 9 before any application of an external load. Supposing the cell 5 is intended to measure a load which may vary progressively from a maximum of W units in tension to a maximum of W units in compression:

With the cell 5 supporting an external compressive load of W units, the compressive force in the column 6 $= P + W/2$ and the tensile force in each side member 9 $= P/2 - W/4$ units.

Since the external compressive load is balanced by the algebraic sum of the loads in the side members 9 and the column 6 then:

$W = P + W/2 - 2(P/2 - W/4) = W$

Similarly considering the cell 5 under an external tensile load of W units then:

The compressive force in column 6 $= P - W/2$ units.

The tensile force in each side member 9 $= P/2 + W/4$ units.

Again the external tensile load is balanced by the algebraic sum of the loads in the side members 9 and column 6 so that:

$W = 2(P/2 + W/4) - (P - W/2) = W$

Although the above values are not strictly correct since they are based on the assumption that the materials are equally flexible or perfectly rigid, they are sufficiently valid to explain the basic principles. Ignoring the more complex relationship between these values due to the elasticity of the materials of the side members 9 and column 6, it follows that the value of the pre-stress applied to the column 6 by the side members 9 must be chosen so that $P > W/2$ by an amount at least equal to the range of loading of the cell in which the unacceptable linearity error exists. In this context, a linearity error of less than 0.2% is considered a negligible error and an error of 0.1% or less will usually be achieved in practice. Taking into account the effects of the modulus of elasticity of the cell materials, the value of P will

require to be a little greater than that given by the simple formula above.

WHAT WE CLAIM IS:—

1. A strain gauge load cell of the kind specified, which is pre-stressed to make it work in the linear part of the gauge output characteristic over a range extending between an external tensile load through zero to an external compressive load, in which the load supporting member is an elastic cylindrical column provided with relatively rigid axial-end cross-pieces which are interconnected either by similar parallel relatively rigid side members respectively disposed symmetrically on opposing sides of the column and parallel therewith, or by a relatively rigid tube co-axially surrounding the column, the side members or tube in the unstressed condition being alternatively either shorter or longer than the axial length of the column in the unstressed condition, the arrangement being such that by reason of the interconnection with the cross pieces and the disposition of the column therebetween, pre-stressing of the side members or tube occurs and pre-stresses the column to an extent which is greater than the sum of half the maximum stress to be applied to the cell as a whole and the stress which must be applied to the elastic column before a linearity error becomes negligible.

2. A strain gauge load cell according to Claim 1, wherein the pre-stressing of the elastic column is in compression.

3. A strain gauge load cell according to Claim 1, wherein the pre-stressing of the elastic column is in tension.

4. A strain gauge load cell according to Claim 2, wherein the elastic load-supporting column is compressed between a pair of opposed cross pieces interconnected by a pair of opposed side members.

5. A strain gauge load cell according to Claim 4, wherein the cross pieces and side members are integral with one another.

6. A strain gauge load cell according to Claim 2, wherein the elastic load-supporting column is compressed between a pair of opposed cross pieces connected to the opposite ends of a tubular member coaxially surrounding the column.

7. A strain gauge load cell according to Claim 3, wherein the elastic load-supporting column is tensioned between and secured to a pair of opposed cross pieces spaced apart by integral or separate side members.

8. A strain gauge load cell according to any one of the preceding claims, in which the column is pre-stressed to an extent whereby the linearity error is 0.1% or less within the operative range of the cell.

9. A strain gauge load cell of the kind specified constructed and arranged substantially as herein described with reference to Figure 1 of the accompanying drawings.

10. A strain gauge load cell of the kind specified constructed and arranged substantially as herein described with reference to Figure 2 of the accompanying drawings.

11. A strain gauge load cell of the kind specified constructed and arranged substantially as herein described as modified with reference to Figure 1 or 2 of the a ccompanying drawings.

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1109176 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

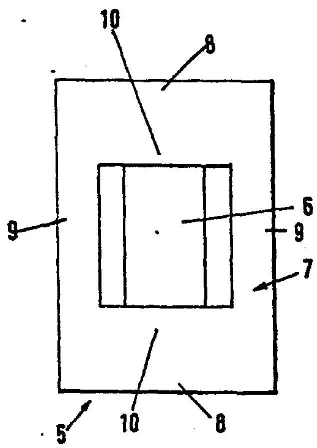

FIG 1

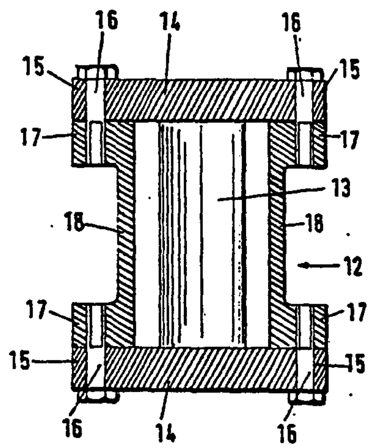

FIG 2